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DISEASES OF WATERMELONS

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FOUNDATION OF MANUFACTURE

IN most of the commercial watermelon-growing districts of the South it is best to select land never previously used for this crop and never exposed to contamination by drainage water, by material from old melon fields introduced in stable manure, or by other means.

Land infested with root-knot should be avoided. Root-knot in the soil can be detected by examining the roots of the preceding crop and of the weeds in the field for galls or enlargements. If these are found, a special rotation of winter grain, velvet beans, corn, and other crops immune to root-knot is advisable.

The blighting of the foliage and the spotting of the melons from anthracnose may be prevented by thorough spraying with Bordeaux mixture.

To avoid stem-end rot the most important measure is the disinfection of the cut stems with a bluestone paste when the melons are being loaded into cars. It is helpful also to cut and burn the weeds along fences and ditch banks and to remove and destroy all cull melons.

DISEASES OF WATERMELONS.[1]

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COOPERATION FOR THE CONTROL OF WATERMELON DISEASES.

THIS bulletin deals primarily with diseases of watermelons as found in the Southeastern States, whence some thousands of carloads are shipped each year to northern markets. The information is, however, applicable to other sections of the country wherever any of the diseases mentioned occur.

The Department of Agriculture is prepared to assist growers in carrying the recommended control measures into effect through its advisory relations with county agents and State extension workers. There is, however, need for a readjustment of marketing conditions and the cooperation of buyers and shippers in securing for the grower a return for his field work in controlling anthracnose and stem-end rot. When cars are bought by traveling buyers, the ownership and responsibility for the melons are shifted at the time of sale. Frequently growers of diseased melons have been known to receive the same price for them as those who have gone to the expense and labor of spraying the vines and treating the fruit to insure a healthy crop. In view of these facts, it is not surprising that farmers have been slow to adopt disease-control measures. During the past few years shippers and railroads have suffered as a result of lack of attention on their part to the relation of watermelon diseases to the carrying power of the crop. There is at this time,

[1] A revision and extension of Farmers' Bulletin 821.

however, a movement toward cooperation between railroads, distributers, and growers that promises great improvement in the watermelon-disease situation.

For convenience in reference and identification of the several diseases, the descriptive key given below has been prepared.

DESCRIPTIVE KEY TO WATERMELON DISEASES.

Symptoms.	Disease.
Diseases of the vine:	
A. The vines lack vigor and the melons remain small; the roots are covered with galls	Root-knot.
B. The vines die at centers; stems near the ground dry up and become brown; there is conspicuous gumming at the base of the stem	Gummy stem blight.
C. The vines wilt suddenly, beginning at the ends of the branches—	
1. Matted white mold is present on the base of the stem	Ground-rot.
2. White mold is absent	Wilt.
D. The leaves show irregular dark spots and shrivel up. (See also "Malnutrition," p. 30)	Anthracnose.
Diseases of the fruit:	
E. The fruit is spotted with small pits	Anthracnose.
F. The fruit decays at the stem end	Stem-end rot.
G. The fruit decays at the blossom end	Blossom-end rot.
H. The fruit decays where it rests on the ground, with abundant white mold	Ground-rot.

WILT.

In most watermelon sections the experience of many years has established the fact that two successive crops of watermelons can not be grown on the same land without risk of failure and that 10 years or more must pass before old melon fields may be replanted. It is more than 25 years since Dr. Erwin F. Smith showed that the cause of these failures is a specific disease, the wilt, and outlined the procedure by which losses may be avoided.

CHARACTERISTICS OF WILT.

The name of the disease indicates its most prominent symptom. Affected vines wilt suddenly and do not recover. Usually one branch after another wilts, beginning at the tip, and dries up until the whole vine is dead. This may occur at almost any time during the growing season, but is most noticeable when the fruit is setting.

Cut the stem, and the woody portion will be found discolored (Fig. 1.) If a microscope were available, the browned areas, which are the water-carrying vessels, would be seen to be plugged with slender, colorless mold filaments, the watermelon wilt fungus.

CAUSE OF WILT.

The cause of wilt is a fungus[2] which attacks only watermelons. It lives in the soil, enters the small roots, and grows up through the water vessels, which it plugs to such an extent as to cause the vine to wilt. After the death of the vine the fungus grows out of the stem at the surface of the ground and there forms multitudes of spores—minute seed bodies—which spread it very widely.

Few soil diseases spread as rapidly as the watermelon wilt or remain longer in infested soil. It is carried by drainage water, on the feet of live stock, in stable manure, and in other ways.

It has a preference for light, sandy soils, and different types of soil vary in their liability to infection and in the length of rotation necessary to free the land of the disease. This is a point to be determined by local experience. Watermelon wilt now occurs practically wherever watermelons are grown in the United States. It is in sections where it is newly introduced that the directions given in this bulletin will be most helpful if followed, as the older sections have learned them by experience.

FIG. 1.—Watermelon wilt. Cross and longitudinal sections of the stem of a diseased plant, showing the blackening of the wood, characteristic of the disease.

CONTROL OF WILT.

The following control measures have all been shown to be of practical importance:

Rotation of crops.—Watermelons must not be planted twice in the same place if wilt prevails. The period which must elapse before the land can be considered free from infection is set by different growers at 10 or 12 years, or longer. This, of course, does not apply to those sections where wilt does not occur and where short-term rotations may be followed.

Control of drainage water.—Land which has received drainage or flood water from a melon field may be considered infested. In selecting land for melons, plant the lower fields first and the hilltops last.

Avoidance of stable manure.—The wilt fungus grows well in stable manure, and a field to which infested manure or compost is applied is almost invariably a failure. Most stables become infested from portions of melon vines brought

[2] *Fusarium niveum* Erw. Sm.

in with hay cut from melon fields after the crop is off and remain so infested from year to year, indefinitely. Consequently in districts where wilt prevails it is advisable to use only commercial fertilizer for watermelons.

Control of live stock.—The wilt is spread also by cattle and horses which range from an old melon field to other fields which may be planted to melons later. Scattered cases of wilt traceable to this cause have been observed to be most frequent along the paths to water and near trees where the animals congregate.

FIG. 2.—Resistant watermelons. A field of Conqueror melons free from wilt on a badly infested field where all other varieties failed.

Resistant varieties.—None of the standard varieties of melons is materially resistant to wilt. A wilt-resistant variety, named Conqueror, has been bred by the Department of Agriculture by crossing the Eden with the stock melon or citron (Fig. 2), and a similar line of breeding continued by the North Carolina Agricultural Experiment Station also resulted in the production of a resistant melon. Neither of these varieties is recommended for general use at present. The Conqueror is an oval, striped melon, a type not popular in the markets, and while of good quality when grown in the sand hills of South Carolina, where it was originated, it has shown a tendency to vary from type in some cases when grown elsewhere. Thus far also, enough new land has been available to furnish an ample acreage for melons. Ultimately it would seem that a resistant variety will be needed, and it is felt that the way has been found to produce one.

ROOT-KNOT.

The watermelon is very susceptible to injury by the root-knot nematode,[3] a pest very widely distributed in the South on most vegetables, cotton, cowpeas, etc., and some losses to melon growers have occurred.

The aboveground effect of root-knot is mainly a stunting or reduction in vigor of vine and size of fruit. The roots are the seat of the injury, and these are greatly swollen, distorted, and knotted. (Fig. 3.)

Root-knot is a pest of old fields, and the practice of growing melons on new land fortunately avoids much loss. Growers however, should bear in mind the susceptibility of this crop to root-knot whenever considering the planting of old fields.

Root-knot can be controlled in a practical way only by a system of rotation with nonsusceptible crops, such as winter grains, corn, velvet beans, and Iron or other resistant cowpeas. For a full discussion of this important matter, consult Farmers' Bulletin 648, "The Control of Root-Knot," which will be sent free upon application to the Department of Agriculture.

FIG. 3.—Root-knot. Melon root, showing galls caused by nematodes.

GUMMY STEM BLIGHT.

Gummy stem blight is a disease that is coming to be of increasing importance not only in the Southeastern States but in the Middle West as well. This disease is marked by the death of the plants from the centers outward. The root just below the ground and the branches leading off are partially killed, browned, and may show the presence of smooth, ash-gray, irregular cankers on which the fruiting bodies of the fungus[4] may be seen as very minute black spots. This browning and dying of the tissues is accompanied by a profuse exudation of red gum. Under weather conditions favorable for the fungus, that is, abundant rainfall and warm temperatures, the disease may progress to such an extent that the entire vine is killed.

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[3] *Heterodera radicicola* (Greef) Müller.

[4] *Mycosphaerella citrullina* (Sm.) Gr.

Frequently, however, the stem-blight fungus does not completely kill the plant, but instead seems to be confined to a partial killing out of the tissues and foliage at the center of the vine. Poorly developed fruits may form on such plants.

This fungus is also able to cause a rot of the fruit, and melons in the vicinity of affected vines are occasionally found to be decaying at the blossom end. Such blossom-end rot has been found on Florida and Georgia melons in New York City, and a few instances have also been noted where this fungus caused a stem-end rot during the period of transit. As the disease develops rather slowly, it seems probable that in those cases where the melons were affected at the market the fruit was in the initial stages of decay when loaded.

CONTROL.

Until more is known about stem blight, control measures can not very well be outlined. There are indications that seed treatment tends to reduce the extent of it. The spray measures recommended for the control of anthracnose should also be effective in preventing the spread of this disease from plant to plant in a field.

GROUND-ROT.

Ground-rot, so called because it affects the side of the melon next to the soil, has been found to be the cause of considerable loss in certain fields examined in Georgia, Florida, and South Carolina. The causal fungus[5] not only produces a fruit rot (Fig. 4) but brings about a wilting of the vine as well. It no doubt occurs in other States, for the fungus is widespread and causes trouble on many different crops.

The first evidence of the disease is likely to be a wilting and subsequent death of plants scattered here and there over the field. This disease may be readily distinguished from stem blight and Fusarium wilt by the matted white mold that grows about the affected root into the soil. In this mold, which is either on or just below the surface of the soil, resting bodies of the fungus, known as sclerotia, are formed. These are about the size of mustard seed and are at first white but change to yellowish brown in color.

In fields where the disease has been noted as a cause of wilt, it is almost certain that some of the melons will become infected through injuries in the portion of the rind that lies next to the soil. On the fruit the disease starts as a small watery discoloration surrounding the wound at which the fungus entered. This spreads very rapidly, the decayed rind breaks, and the matted white mycelium of the fungus grows out over the surface of the decayed area. The character-

[5] *Sclerotium rolfsii.*

istic seedlike sclerotia are soon formed, and when these are present there is no difficulty in identifying the trouble.

Growers should avoid loading melons that are starting to rot.

CONTROL.

Seed treatment may be of some assistance in preventing the spread of this disease to new territory. Crop rotation as practiced for the control of wilt should also be beneficial, although the fungus attacks such a wide range of hosts that once started in a field the chances are that it will live over in the soil for years. Care should be taken not to scatter the seedlike bodies over the field during the process

FIG. 4.—Advanced stage of watermelon ground-rot. Note abundant development of young white sclerotia, also mature ones (at arrow).

of removing diseased vines, for these sclerotia perpetuate the fungus. It may possibly be worth while to put gasoline on such vines and burn them.

ANTHRACNOSE.

APPEARANCE OF DISEASED VINES.

Anthracnose is caused by a microscopic plant, a fungus known as *Colletotrichum lagenarium*. Vines attacked by this fungus may be recognized by the numerous irregular black spots which appear on the leaves. When heavily infected, the foliage tends to shrivel and curl, and after a period of heavy rainfall, when the disease has spread rapidly, farmers often speak of their field as having been "burned over," owing to the fact that the leaves in large areas have

been crisped and blackened by the fungus. Many growers attribute the injury to excessive rainfall. This is in part true, as moist conditions are necessary for the growth and development of the fungus and consequent spread of the disease. If one examines diseased leaves carefully after a prolonged period of wet weather during which the leaf tissue has been kept moist, so that the fungus has had an opportunity to develop, it is often possible to see an orange-pink layer partially covering the black spots. This is due to the presence of countless spores, microscopic fungous seed bodies, which spread the disease.

FIG. 5.—Watermelon anthracnose on the fruit.

APPEARANCE OF DISEASED FRUIT.

Very young fruits when affected by anthracnose are likely to become deformed, and this is usually accompanied by the formation of irregular black sunken spots or light-green pimples with a yellow cast in the center. Pink spore masses often form on these at an early date.

If infection does not occur until the melon has reached a weight of about 10 pounds or more the trouble is marked by small pimples or larger flattened elevations on the rind (Fig. 5). These spots are often spoken of by farmers as "rain checks," "smallpox," "pock marks," etc. When conditions are very moist in the field or when such melons are loaded and held for some time in a freight car bedded with wet straw or sawdust, these pimples become sunken, enlarged, and covered with masses of pink spores. Such spots often furnish a point of entrance to other organisms of decay.

METHODS BY WHICH THE DISEASE IS SPREAD.

There are numerous ways in which the spread of anthracnose may be accomplished. Spores may be spattered by raindrops to leaves near by or washed to the ground, where they are carried along to other plants by drainage water. Laborers often disseminate the

disease, particularly if culls are removed or melons harvested while the vines are wet with dew or rain. Under such circumstances, the hands and clothing are likely to carry spores from diseased vines to healthy ones. If spores lodge on the melon itself the characteristic anthracnose lesions form.

ANTHRACNOSE CARRIED ON THE SEED.

When the seed is harvested from diseased melons, it is likely to be contaminated with anthracnose spores, with the result that the young plant is almost certain to be affected with the disease. This can be prevented by disinfecting the seed before planting. It must be remembered, however, that the fungus may live over winter on dead vines and fragments of the fruits of cucumber, muskmelon, and watermelon, so that even if the plant is healthy at the start the disease may obtain a foothold in the field from a source other than the seed. Barnyard manure sometimes carries the disease when it comes from a yard in which melons were fed to the hogs. On account of the fact that infection may come about in several ways, seed treatment alone does not insure a healthy crop. It is a measure that should be carried out in connection with a good spray program.

METHOD OF TREATING THE SEED.

A 1 to 1,000 mercuric-chlorid (corrosive-sublimate) solution should be used for treating watermelon seed. This solution may be prepared conveniently from the standard mercuric-chlorid tablets sold by druggists. *It should be remembered that mercuric chlorid when taken internally is extremely poisonous.* As the solution will attack various metals, it should be used in either a glass, earthenware, or wooden receptacle.

When making the treatment it will be found convenient to put the seed to be disinfected in a loosely woven bag, care being taken not to fill this bag more than three-fourths full, as some space will be needed to allow for the swelling of the seed. *Immerse the seed for 5 minutes and no longer.* Then wash thoroughly in running water for 15 minutes or in several successive changes of water. The seed must be stirred while being treated and also during the washing process. After washing, the seed should be spread out so that it will dry rapidly. If it is to be replaced in the seed bag, this must also be immersed in the mercuric-chlorid solution and then washed and dried. The same solution should not be used for treating more than two lots of seed.

In case associations of seedsmen or growers wish to treat seed on a large scale, the United States Department of Agriculture will, on application, give directions for preparing the solution in quantity from mercuric-chlorid powder.

EFFECT OF THE DISEASE ON YIELD.

Assuming that there is for a start a single diseased vine in the field, the effect on the crop is largely dependent on weather conditions. Abundant rainfall leads to the rapid spread of the disease. If heavy rains prevail early in the season, it is possible that the foliage will be completely destroyed before any fruit is matured. It is more often the case, however, that the trouble rapidly spreads shortly before or during the shipping season in a given locality, as this is likely to be a period when showers are frequent in the Southeastern States. Under these circumstances much of the fruit shipped is removed from dead vines and is likely to be sunburned, severely

FIG. 6.—Watermelon anthracnose causes waste in transit. New York melon yards, Kearney, N. J., where severely affected melons often have to be hauled to the dump.

spotted, and of inferior quality. In such cases the shipment may result in loss, not only to the grower but to the railroad and dealer as well.

ANTHRACNOSE MAY LEAD TO ROT IN TRANSIT.

Study of findings made by the inspection service of the Bureau of Markets and Crop Estimates during the past two years shows that great waste is caused by attempts to ship badly spotted fruit. Other organisms of decay gain entrance through the anthracnose spots, and the melon is often completely rotted on arrival at market. Whole carloads of such melons were seen in New York during the past season as a result of southern growers shipping diseased fruits. Figure 6 illustrates such a car in process of being unloaded, showing the use of pitchforks and scoop shovels to remove the rotten melons.

CONTROL OF ANTHRACNOSE BY SPRAYING.

The most practicable method of reducing the damage done by anthracnose is to spray the watermelon vines with 4–4–50 Bordeaux mixture. If anthracnose spores are carried to healthy melon vines, they will become diseased unless protected by a coating of spray mixture, which prevents the germination of these spores and the development of the fungus. (Figs. 7 and 8.) Thorough applications of 4–4–50 Bordeaux mixture will prevent the spread of anthracnose and will help to control other diseases of the crop.

WHEN TO SPRAY.

One must remember that spraying is a preventive, not a cure, and that it is effective only to the extent that the entire surface of the

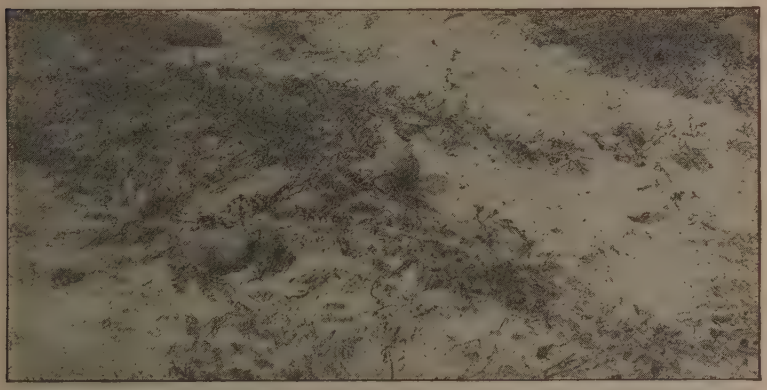

FIG. 7.—Ineffectual spraying for watermelon anthracnose. This field was sprayed once with 1–4–50 Bordeaux mixture, which proved too weak to control the disease. Compare with figure 8.

healthy plant is kept covered with a thin coating of the spray solution. Knowing this and the fact that the disease spreads rapidly during and immediately after rainy weather, the farmer must choose the proper time for the application. The following schedule will serve as a guide for making this selection:

Make the first application when the vines begin to run.

Spray the second time about one week after the first melons have "set" on the vines.

Make a third application about two weeks after the second.

If rains are frequent just preceding and during the loading season, it is sometimes profitable to continue spraying until the crop is harvested.

When anthracnose appears and the above schedule has not been used, try these emergency measures: Spray with Bordeaux mixture immediately and repeat the operation about 10 days later. If rains

are frequent at this time, additional applications may be required. The farmer must judge with regard to the number of applications necessary. In a dry season two or three may be sufficient, while in a wet season it has been found necessary and profitable to spray as many as six times.

HOW TO SPRAY.

THE SPRAY PUMP.

The man who intends to spray his watermelons should prepare well in advance. A good spray pump should be secured, and his laborers should be made thoroughly familiar with the operation of the equipment. If the grower has a small acreage he may be able to unite with one or two neighbors in the purchase of a pump

FIG. 8.—A field in which the watermelon vines were sprayed five times with 4–4–50 Bordeaux mixture. The foliage was heavy at shipping time, and the melons were not spotted.

and materials. In order that sufficient pressure may be maintained gasoline-power equipment is almost essential for successful work with watermelons, although if the acreage is small, 10 or 15 acres, it may be necessary for purposes of economy to use a hand pump. Growers in certain sections of Florida and in central Georgia have found that the outfits used for spraying citrus fruits, pecans, and peaches may be adapted for use with watermelon vines. Orchard apparatus, however, is rather heavy for use in sandy fields. Several firms manufacture light gasoline-power outfits with the tanks mounted on two wheels, and these have many advantages for work with watermelons, particularly if stumps are abundant. (Figs. 9 and 10.) In buying an outfit, care should be taken to provide all the clearance possible between the ground and the bottom of the tank.

Since Bordeaux mixture contains copper sulphate the pump should be lined with brass.

EQUIP THE SPRAYER TO SUIT THE FIELD IN WHICH IT IS TO BE USED.

The number and arrangement of leads of hose depend on the field in which they are to be used and the method of spraying. In general, the spray is applied by driving down a middle and spraying two or more rows on each side of the machine. (Fig. 11.) If the rows are 10 feet apart and the vines are kept turned back throughout the season to give driveway in those middles that are to be used for this purpose, very little injury will be caused by the passage of the machine. Folding booms (Fig. 12) will usually

FIG. 9.—Filling the spray tank in the field. This type of pump, in which the tank is mounted on two wheels, is manufactured by several companies. Such a machine is particularly well adapted for use where stumps are abundant. Time is saved by hauling the mixture to the field in a tank or in barrels, so that the pump may be kept in continuous operation until the field is covered. A galvanized-iron bucket, like the one shown, should never be used for dipping Bordeaux mixture, as the mixture attacks iron. A wooden bucket should be used instead.

be found useful to support the hose. In some cases, however, stumps and trees may be so abundant as to prevent the use of booms, in which case it will be necessary to employ boys to carry the hose in order to prevent injuring the vines. (Fig. 10.)

APPARATUS, SPRAYING MATERIALS, AND LABOR REQUIRED.

The following outline has been prepared for the purpose of assisting the grower in the purchase of apparatus and supplies and in planning his work:

(1) Gasoline-power spray pump, able to deliver the spray mixture to six nozzles at 150 pounds pressure or more.

(2) Three leads of ⅜-inch hose, one 15 to 20 feet long behind the machine and the others each 30 feet long, extending one on each side of the machine and supported by a folding boom. Extra lengths of hose should be kept on hand.

(3) Three bamboo extension rods, 4 to 6 feet long, each equipped with a faucet cut-off at the hose end and with Y fittings at the nozzle end.

(4) Six angle (45°) disk nozzles, two for each extension rod. Extra nozzles should be kept on hand.

(5) Four or more wooden barrels for use in mixing the spray solution.

(16) Wooden buckets for dipping the bluestone solution.

(7) A strainer for the Bordeaux mixture made of brass wire having 18 meshes to the inch.

(8) Copper sulphate (bluestone).

(9) Quicklime (stone lime not air slaked). If necessary, hydrated lime may be used.

In ordering the spraying materials it is best to estimate in each case that about 4 pounds per acre will be required for each application.

The force required to operate such an outfit as that recommended will consist of a driver, three men to apply the spray, and a team of mules or horses. (Fig. 11.)

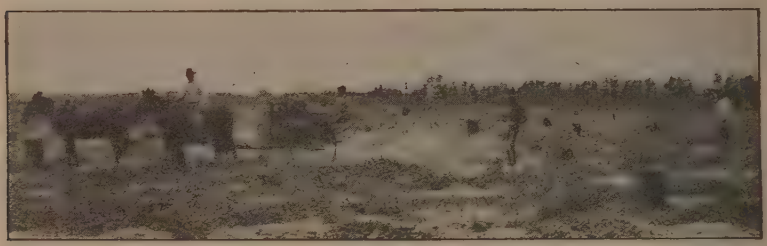

FIG. 10.—The pump in operation. As melons are frequently the first crop planted on new land, stumps are likely to be numerous. In such fields it is best to use a 2-wheeled machine, with the greatest possible clearance between the ground and the tank.

It is often convenient to have two additional men for preparing the Bordeaux mixture. If this work is done at some distance from the field, time may be saved and wear on the sprayer avoided by having the mixture hauled to the field in barrels. Boys to carry the hose are necessary when the booms suggested are not used.

If the outfit is handled effectively 25 to 50 acres and even more may be sprayed in one day.

COST OF SPRAYING.

In 1919 the cost of spraying an acre of melon vines once was about 95 cents. This includes the cost of labor and materials, but does not take into account the depreciation of the machinery.

PREPARATION OF BORDEAUX MIXTURE.

In order that spraying may be accomplished in an effective and economical way, it is necessary that the application be made quickly as well as thoroughly. Consequently, it is well worth while to pre-

pare for mixing the solution in advance of the day on which the work is to be done by making stock solutions from which the Bordeaux mixture can be prepared quickly.

Purchase quicklime (not air slaked) and copper sulphate early in the season, in such quantities as to secure wholesale prices. Provide wooden buckets for dipping the copper-sulphate and Bordeaux solutions and also four or more 50-gallon wooden barrels. These should be marked inside by driving nails to indicate the water line when containing 25 and 50 gallons of water. Then one or more days before spraying, make stock solutions of bluestone and lime, proceeding as follows:

Place 50 gallons of water in a wooden barrel and dissolve 50 pounds of bluestone in it. This can be done conveniently by suspending a gunny sack containing the bluestone so that the bottom is just below the surface of the water. About 24 hours will be required for the chemical to dissolve. Cover the barrel to prevent evaporation, or dilution in case of heavy rainfall. One gallon of the resulting stock solution will contain 1 pound of bluestone.

FIG. 11.—The 4-wheeled sprayer shown in Figure 12 in operation. Four men are required to handle the outfit. One drives, the man behind sprays the first row on each side of the machine, and the other two men the second and third rows, right and left, six rows in all. The man in the rear is applying the spray by directing it sidewise, holding the nozzle slightly above the foliage. This insures good penetration of the foliage.

Place 50 gallons of water in a second barrel. Use a sufficient quantity of this water to slake 50 pounds of quicklime and add all of the freshly slaked lime to the water remaining in the 50-gallon barrel, stirring thoroughly. One gallon now contains 1 pound of lime.

These stock solutions will make a sufficient quantity of Bordeaux mixture to cover about 12 acres of well-grown vines. If the acreage is greater than this, larger quantities of the stock solutions should be prepared, using the proportions specified above.

When ready to spray—

(1) Pour 4 gallons of the copper-sulphate stock solution into a barrel and add water to make 25 gallons.

(2) Stir the stock solution of lime; place 4 gallons of this in another barrel and add water to make 25 gallons.

(3) Pour these two solutions through a strainer into the spray tank. If a hand pump is used stir the mixture well; if a power sprayer is used operate the agitator while running the mixture into the tank.

The result of the above procedure will be 50 gallons of 4–4–50 Bordeaux mixture, a sufficient quantity to cover about 1 acre of well-grown vines. If a large acreage is to be sprayed it is often found convenient to use larger tanks and to elevate these on a mixing platform in such a way that the stock solutions may be piped instead of dipped and the resulting dilutions allowed to run into the spray tank by gravity.

In order to make sure that the copper sulphate is properly neutralized by the lime, Bordeaux mixture may be tested by what is known as the ferrocyanid test. An ounce of yellow prussiate of potash is

FIG. 12.—A 4-wheeled power sprayer rigged with three leads of hose. The homemade folding boom saves the expense of employing a boy to hold the hose.

dissolved in a pint of water, and a drop of this solution is allowed to fall on the surface of the spray mixture. If free copper is present the drop will immediately turn reddish brown in color. Lime milk should then be added until the brown color fails to appear. If the reaction is complete the yellow prussiate of potash solution will remain a clear yellow until it disappears into the mixture.

STEM-END ROT.

A rapid decay, usually beginning at the stem end and developing during transit to market, has caused losses during recent years that for some sections have been perhaps more serious than any other melon disease. Many cars have reached their destination with 75 to 95 per cent of their contents spoiled. On one day in 1915 in 100 cars

on the tracks in a large northern market an average of 25 per cent of the melons was decayed with stem-end rot. (Fig. 13.)

Since 1917 the Department of Agriculture has urged in the Southeastern States the application of certain control measures, the most important of which is stem treatment. While in 1921 there seemed

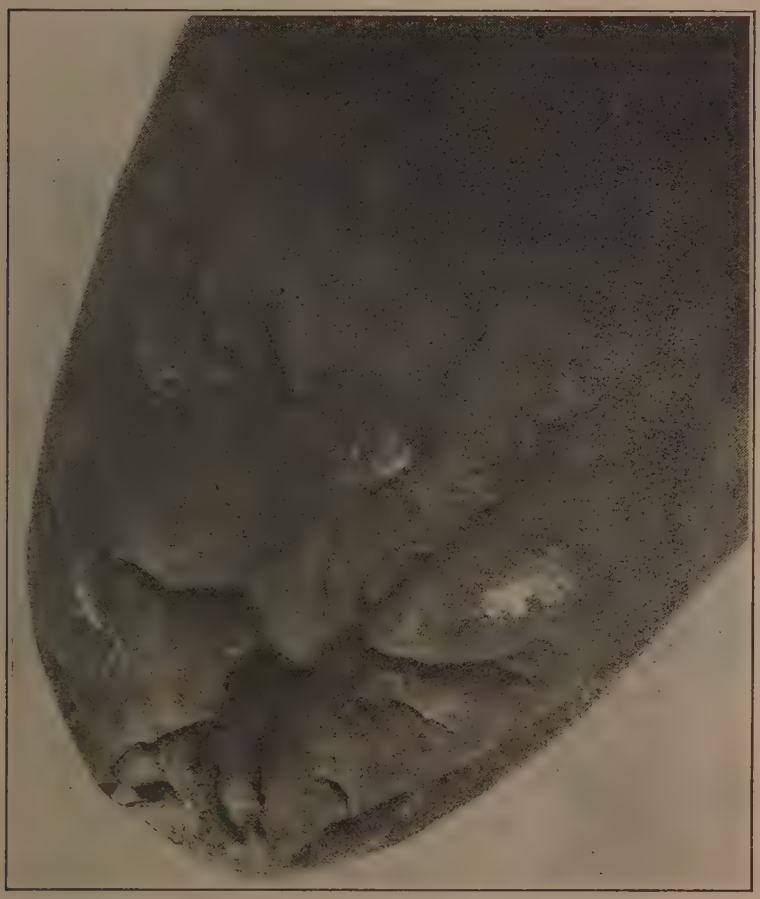

FIG. 13.—Part of a watermelon, showing stem-end rot.

to be a reduction of the losses due to this disease, nevertheless the wastage in individual cars was often very heavy. An idea of the extent of the losses can be obtained from a study of the summary of the inspection reports made by inspectors of the Bureau of Markets and Crop Estimates in those cars that were examined at northern destinations during the season of 1921. (See Table 1, p. 28.)

So accustomed have the melon handlers become to this disease that it is a common practice when unloading to test every melon as it is passed out of the car by exerting pressure with the thumb at the stem end. If the rind gives way, the melon is rejected.

The first indication of the trouble is a browning and shriveling of the stem. At this stage the stem has a hollow feeling when pressed between the fingers. Decay of the melon begins at the point of attachment of the stem, where the flesh softens and takes on a water-soaked appearance. A band of decay progresses down the fruit at the rate of half an inch to 1½ inches or more a day and under moist

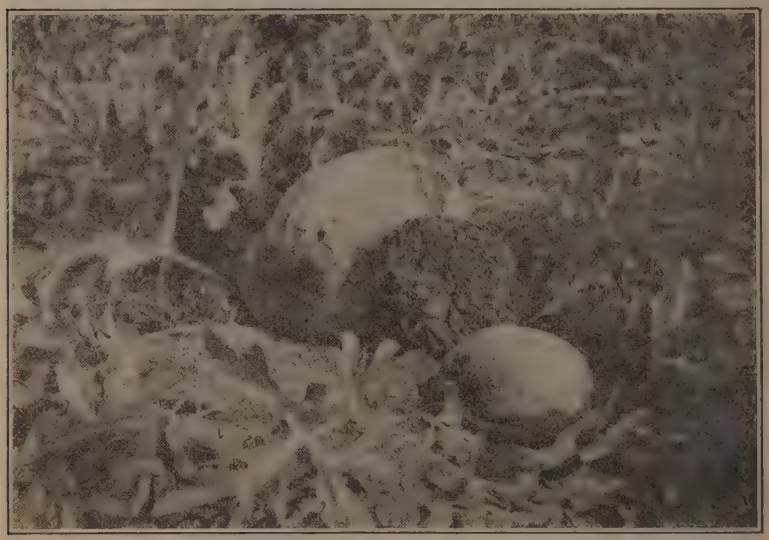

FIG. 14.—Watermelon stem-end rot. Decaying and mummifying culls in the field. These are a source of infection to the remainder of the crop.

conditions soon becomes covered with a dark-gray mold. (Fig. 13.) The flesh of the melon becomes soft and slimy.

The same type of decay may begin at a point on the side of the melon where there is a wound or bruise, and it is very common in the fields as a blossom-end rot. These melons, if left in the field, become wrinkled, black mummies and are dangerous centers of infection. (Fig. 14.)

CAUSE OF STEM-END ROT.

Stem-end rot is due to a fungus[6] closely related to or identical with species which cause a stem-end rot of citrus fruits, a decay of sweet potatoes, a cotton-boll rot, and other plant diseases. They are

[6] *Diplodia* sp.

all alike in being wound or weakling parasites; that is, they will not attack a living plant or fruit unless it is weakened or dying from some other cause or has been cut or bruised.

The stem-end rot fungus is common on ripe or dying vegetation in and around the melon fields, especially on cotton and corn stalks, coffee weed, and old melon vines. These plants become covered with the black fruiting bodies of the fungus (Fig. 15), in which countless spores are borne and from which they are scattered by the wind. In this manner the fungus lives over winter and is carried in the spring

FIG. 15.—Watermelon stem-end rot fungus. Section through a spore case (pycnidium), showing the production of spores. (Greatly magnified.)

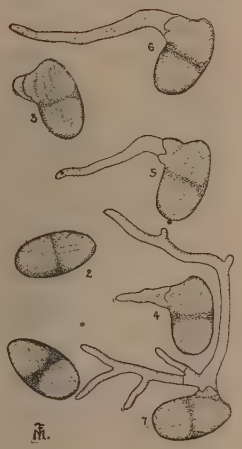

FIG. 16.—Spores of the fungus causing watermelon stem-end rot. Spores taken from a freight car which had contained decayed melons are shown at 1, 2, and 3. Six months later 5 per cent of them were alive and germinated when moistened, as shown at 4, 5, 6, and 7. ×360.

to infect the blossom ends of imperfect melons or the cut stems of culls. Such melons, decaying in the field, are the chief sources of infection, as they become literally covered with masses of spores. Figure 16 shows these spores magnified 360 times and illustrates their method of germination and the beginning of the mold thread which infects the melon.

INFECTION AND DEVELOPMENT.

Infection may occur in the field on the freshly cut stem and in any injury of the rind, such as cuts made by knives at harvest season, anthracnose spots, rabbit injury, and wounds caused by the pickle worm. During transit, providing the fungus is present on the car bedding or if decayed melons on which the fungus is fruiting are in the car, infection may take place at any one of the injuries listed above. Decay may also follow deep cuts and bruises caused by careless handling at loading time or brought about by the rubbing of melons against the walls of the car.

Since the cut stem is a wound that is present on all watermelons, the chances are greatest for the rot to start at this point. As a matter of fact, this is what really happens, so that the disease has come to be known as stem-end rot.

When a melon is cut from the vine, sap exudes from the cut stem and provides ideal conditions for the germination and development of the fungous spores. Since the spores are wind borne, they are abundant in the air and are likely to find lodgment on the cut stems. The knives and hands are also carriers of infection.

An idea of the rate of progress which this disease makes after the spores have reached the cut stem may be obtained from the following record of a Watson melon that was inoculated after the stem was recut and kept in a well-ventilated place at a temperature ranging from 75° to 90° F.:

In 42 hours after inoculation three-eighths of an inch of the stem was softened.
In 66 hours after inoculation three-fourths of an inch (the entire stem) was softened.
In 90 hours after inoculation watery discoloration of the rind was evident to a line approximately 1½ inches distant from the base of the stem.
In 114 hours after inoculation the rind became decayed to a line 3½ to 4 inches distant from the stem, and the tissue immediately surrounding the stem was blackened with the fruiting fungus.

Lack of ventilation, abundant moisture, and high temperatures lead to rapid development of the disease, while good ventilation and cool weather retard its progress.

Individual melons vary with regard to the length of time required for the fungus to cause a visible softening of the rind about the stem. Figure 17 shows five Watson melons which were inoculated at the same time after the stems had been cut to a ¾-inch length. In the case of melons Nos. 1 and 2 the inner white line A marks the outline of the decayed area three days after inoculation; 24 hours later, or four days after inoculation, decay was evident on the remaining three melons and had extended over the area included in the white lines B, while on melons Nos. 1 and 2 the decay had advanced to the second white mark B, a distance varying from half an inch to 1½ inches.

Study of the above records makes it clear that in three to five days the fungus may do considerable damage. When one realizes that infection usually takes place in the field and that this may happen during the early morning, while the car may not move until 12 or more hours have passed, it is not difficult to understand the high percentage of decay that is sometimes evident at the end of a haul lasting four or five days.

RELATION TO FERTILIZERS.

Stem-end rot is not due, as many think, to the use of large quantities of fertilizers or to the excessive use of nitrates or any particular ingredient. Growers may safely continue to fertilize their watermelon fields in the manner that experience has shown to produce the earliest and the largest crops.

RELATION TO VARIETIES.

All varieties of watermelons tested have proved to be subject to stem-end rot. There is no reliable evidence to indicate that the varieties now in cultivation have deteriorated or that those formerly

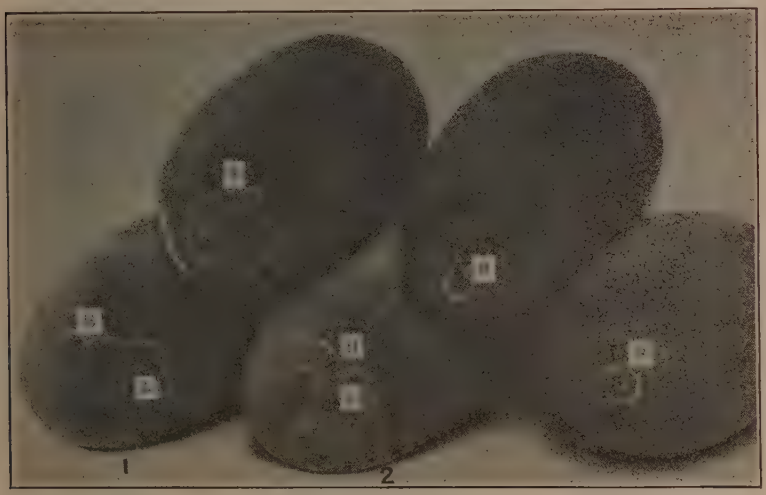

FIG. 17.—Rate of progress made by stem-end rot varies with individual melons. The five melons pictured above were inoculated at the same time. The outlines marked *A* show the visible development of the rot at the end of three days; *B*, the decayed areas at the end of four days.

grown were less liable to this disease. The breeding of resistant varieties is not one of the measures indicated for its control.

RELATION TO MATURITY.

Watermelon fruits are subject to stem-end rot at all stages of development. Green fruits, if infected, will decay as quickly as ripe fruit. The shipping of immature melons, therefore, will not avoid stem-end rot.

RELATION TO CHEMICAL INJURY.

Before the nature of stem-end rot was understood, the losses were charged to the presence of lime, salt, and fertilizer residues on the

walls of the cars in which melons were shipped. Extended experiments have now shown that injuries from such substances are not common and that the effect produced by chemicals can be readily distinguished. It is confined, in the first place, to melons that have been in contact with car walls or floors, and, in the second place, to the sides of the melons which are injured; or, in cases where the fertilizer residues were wet, there may be shallow brown depressions in the rind, which do not decay until fungi have gained entrance.

Chemical injury (Fig. 18) has been found to cause a very small fraction of the losses among watermelons at terminal markets. It can be avoided by cleaning the cars thoroughly before loading them with melons and by the use of a strong paper for lining.

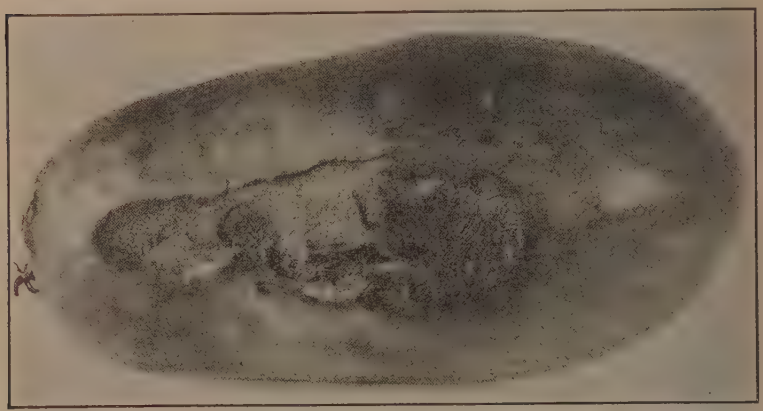

FIG. 18.—Watermelon injury caused by contact with fertilizer on car walls, subsequent bruising, and the entrance of fungi.

CONTROL MEASURES.

The prevention of stem-end rot is to be accomplished by keeping the spores of the causal fungus from germinating on the cut stem. Two lines of action are advisable: (1) Field sanitation, to reduce the danger of infection, and (2) stem-end treatment with a disinfectant.

CLEAN UP THE FIELDS.

It has been shown that dead vegetation of nearly all kinds is likely to harbor the stem-end rot fungus. The first step, therefore, is to cut and burn the weeds and rubbish in the fence rows and along ditch banks. This should be done in the winter. Deep plowing, to turn all the vegetation in the field so far under the ground that it will not be exposed by next season's cultivation, also should be helpful. Both these measures are in any case demanded by good farm practice, particularly in the boll-weevil districts.

GATHER AND DESTROY ALL CULL MELONS.

During the growing period the fields should be gone over once a week and all imperfect or cull melons, blossom-end rots, etc., carried out, because if left to decay in the field they will infect the rest of the crop. Probably the most practicable method of disposing of these culls is to feed them to hogs, since stable manure should not be used on melon fields in any case on account of wilt. The carts used for hauling these diseased melons should be washed subsequently with a 2 per cent solution of bluestone.

SPRAY AS FOR ANTHRACNOSE.

The methods advised on page 13 for anthracnose control will be helpful against stem-end rot, as the fungus which causes the latter disease does not attack a healthy melon vine, but will grow on leaves and stems killed by anthracnose and thence be carried to the melons.

HARVESTING METHODS.

The cutters must never touch or cut into a decayed melon. Knives may be disinfected in a 2 per cent formaldehyde solution. Have the melons cut with the longest possible stems, as it takes longer for the fungus to grow up a long stem and it makes the second cutting at the car easier. Haul the melons to the car without delay. Fruits left in the fields until the next day may become infected in spite of the treatment. Handle carefully to avoid breaking or splitting the stem and to avoid bruises. Open the car ventilators, as this tends toward better keeping. See that the bedding is dry, as melons loaded on wet bedding are more likely to decay.

STEM TREATMENT AT THE CAR.

Since it is improbable that all infection can be prevented by field sanitation, the most important control measure is the disinfection of the freshly cut stem at the time of loading the car, using a paste that will adhere and for the quantity used be nonpoisonous and practically invisible. Such a material is starch paste with bluestone. It may be prepared in 1-gallon lots as follows, using a kettle of sufficient size of enamel ware, as the bluestone attacks iron or tin: Place 3½ quarts of water and 8 ounces of bluestone in the kettle and bring the mixture to the boiling point over a good fire. While it is heating, mix 8 ounces of laundry starch with 1 pint of cold water, stirring until a milky solution free from lumps is obtained. As soon as the bluestone is entirely dissolved and the solution boiling hot, add the starch mixture, pouring it in a slow stream and stirring the hot solution vigorously to prevent the formation of lumps. Continue boiling and stirring the mixture until the starch thickens

evenly. It may be tested at intervals by allowing it to run from the end of the paddle. It should not require that the mixture be boiled more than one or two minutes after the addition of the starch to bring it to the right thickness.

The resultant paste should be used fresh; and as 1 quart is sufficient to treat a carload of melons, it may be desirable to make the mixture in batches of 1 or 2 quarts. If this is done, care must be taken to observe the proportions outlined above.

During the last two years a commercial disinfectant paste powder has been distributed throughout the Southeast. When this is used, care should be taken to add boiling water in the exact amount recommended by the manufacturers. Cold water fails to dissolve the blue-

FIG. 19.—Stem treatment—I. Recutting the stem before the application of the disinfectant paste. Sufficient length should be removed to leave a healthy green surface, but care should be taken to leave the stem as long as possible.

stone immediately; and unless the correct amount of boiling water is used, the fungicide will either be too weak to be effective or so strong that it will injure the fruit.

It is recommended that the treatment be applied at the car, for experiments with stem treatment in the field were less effective because the subsequent handling rubbed off the paste or split the stem.

The following method has proved to be practical and effective. As the melons are packed in the car, have the stem ends turned outward, while a second man or boy with a sharp knife cuts off a portion of the stem and applies a dab of paste to the fresh surface. One man can apply this treatment without interfering with the speed of loading and can keep up with two packers.

To summarize the matter, when properly applied stem treatment consists of two steps: (1) Recutting the stems of the melons at the time of loading (Fig. 19) in the car, so that a healthy, firm, living surface is exposed; (2) application of a homemade or commercial disinfectant paste to the freshly cut stem. (Fig. 20.) This should contain 6 per cent bluestone as a fungicide. Prepared commercial Bordeaux pastes are not satisfactory owing to the unsightly appearance of the mixture when dry. The measure is not effective when melons are loaded with dead stems, as the fungicide is of service only when it forms a barrier between the freshly cut surface of a healthy green stem and infection from without. Care should be taken to apply the paste to the cut stem only. Melons smeared with the disinfectant are unsightly.

FIG. 20.—Stem treatment—II. Applying the disinfectant paste to the freshly cut surface of the stem.

CAR DISINFECTION.

When freight cars have contained decayed melons or yard refuse they should be cleaned and disinfected before reloading with melons. For this purpose a 2 per cent solution of bluestone, applied with a spray pump to the interior walls, ceiling, and floor, will be found satisfactory. Five gallons will be required for each car and the time of two men for 20 minutes.

TRANSPORTATION PROBLEMS.

The average watermelon grower hardly needs to have his attention called to the losses in yield that are caused by plant diseases. Owing to the fact that he seldom sees his crop at the market, however, it is not surprising that the farmer often thinks that state-

ments made with regard to transportation losses are somewhat exaggerated. Since the food products inspection service of the Bureau of Markets and Crop Estimates was established shippers as well as carriers and receivers have been able to inform themselves accurately with regard to the condition of cars on arrival at destination. On payment of a $4 fee those who have a financial interest in a shipment are entitled to a Government inspection. Applications may be filed by telegraph if necessary. (For complete information with regard to this inspection service write to the Bureau of Agricultural Economics, Washington, D. C.) During 1921 over 1,500 carloads of watermelons were examined. A study of conditions found in these cars shows that watermelon diseases take a heavy toll in transit. After unloading, the diseased melons from a car may look much like those shown in Figure 21. An analysis of inspections made on watermelon shipments from four States during 1921 is given in Table 1.

TABLE 1.—*Carload inspections of watermelon shipments from four States made in 1921 by the inspection service of the Bureau of Markets and Crop Estimates.*

[Data based on the proportion of diseased melons found.]

Items of comparison.	Origin of shipments.			
	Georgia.	South Carolina.	Florida.	North Carolina.
Number inspected.....cars..	632	259	79	52
Stem-end rot:				
Having diseased melons[1].....do....	442	150	60	37
Having 5 per cent or over of disease.....do....	372	122	44	21
Having 10 per cent or over of disease.....do....	216	68	29	8
Having 25 per cent or over of disease.....do....	53	18	9	2
Average disease content.....per cent..	8.3	6.8	10.1	4.9
Anthracnose:				
Having diseased melons[1].....cars..	258	199	23	23
Having 5 per cent or over of disease.....do....	252	195	23	22
Having 20 per cent or over of disease.....do....	139	122	13	9
Having 50 per cent or over of disease.....do....	68	52	4	3
Average disease content.....per cent..	13.8	26.1	7.5	8.7
Soft rot (from several causes):				
Having diseased melons.....cars..	63	127	10	34
Having 5 per cent or over of disease.....do....	50	111	9	22
Having 10 per cent or over of disease.....do....	26	86	4	17
Having 25 per cent or over of disease.....do....	6	32	3	4
Average disease content.....per cent..	0.7	9.0	1.6	7.1

[1] The totals of cars containing diseased melons do not include cars in which the disease referred to was so infrequent as to be considered as only "occasional."

Examination of Table 1 brings to light transit losses due to three main causes, namely, anthracnose, stem-end rot, and soft rot. The preceding section on anthracnose makes clear the relation of this disease to the successful marketing of the crop. Under the heading "soft rot" the inspector includes several decays, among which are

ground-rot, bacterial rot following anthracnose, decay on the side of the melon caused by the stem-end rot fungus, and Rhizopus rot. Most of the trouble with the soft rots originates either with an attempt to ship melons that are severely spotted with anthrac-

FIG. 21.—Loss in a car of watermelons due to anthracnose and stem-end rot.

nose or as a result of the wounding and bruising of melons by careless loading methods.

MINOR DISEASES.

The wilt, root-knot, gummy stem blight, ground-rot, anthracnose, and stem-end rot already described are the only diseases which in-

fluence in a large way the culture of watermelons. Some other troubles, however, are met with occasionally, and these may be mentioned briefly.

Macrosporium[7] *leaf-spot*, a fungous disease, is found in almost every locality where melons are grown. While this leaf-spot is common on foliage about the basal portion of the plant, it apparently causes little damage. Farmers often mistake the trouble for anthracnose, although the brown, irregularly rounded, and concentrically ringed spots really bear little resemblance to that disease. Early spraying tends to check development of this trouble.

Bacterial wilt,[8] a serious trouble of cucumbers, occasionally attacks watermelons. Most cases of wilt in watermelons, however, are of the Fusarium type described on page 4. The outward effects of the two diseases are much alike, but if one cuts the freshly wilted stem and on touching the finger to the exudate finds that it can be drawn into fine mucilaginous strands, it may be concluded that bacterial wilt is present.

Downy mildew,[9] a leaf disease producing an effect similar to anthracnose, sometimes occurs, though it is more especially a cucumber trouble. Downy mildew does not attack the fruit. It is controlled by the spraying measures advised for anthracnose.

Malnutrition produces a leaf spotting distinguishable from anthracnose in that the spots are lighter brown and are located around the leaf margins and between the veins. This trouble is attributed to a lack of potash.

Blossom-end rot is very common in most fields, but has been little studied. It seems to begin with an imperfect fruit, possibly due to defective pollination. Such culls are later invaded by decay-producing fungi. The fungus of stem-end rot is perhaps the most common, but other fungi also occur. Control measures consist in the prompt destruction of culls, to get rid of infection.

SUMMARY OF CONTROL MEASURES.

Loss from *wilt* is avoided by planting on land not previously used for watermelons, with precautions against the use of infested stable manure and spread by drainage water and live stock.

Losses from *root-knot* can be prevented by the use of land free from infestation by this pest.

Anthracnose is controlled by thorough spraying with Bordeaux mixture during the month preceding the maturity of the crop.

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[7] *Macrosporium cucumerinum* E. and E.

[8] *Bacillus tracheiphilus* Erw. Sm.

[9] *Pseudoperonospora cubensis* (B. and C.) Rostow.

For *stem-end rot* the most important measure is the disinfection of the cut stems as the melons are being loaded into cars.

Infection by the organisms which cause *anthracnose*, *gummy stem blight*, and *ground-rot* may be reduced by seed disinfection, provided the crop is planted on soil that is free from these diseases and in case barnyard manure containing the disease-producing organisms is not applied.

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